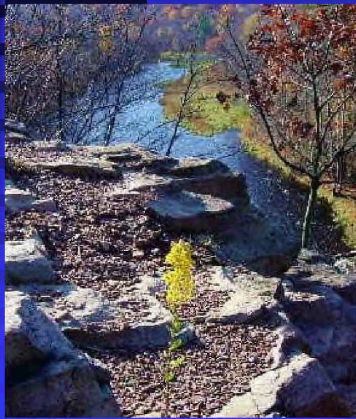


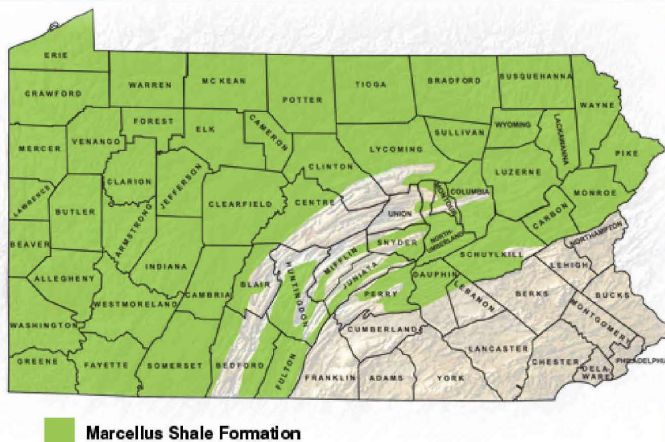
# Getting The Waters Tested The Marcellus Shale Factor



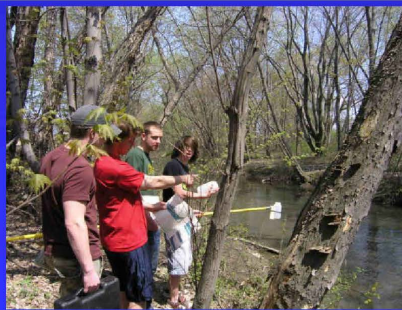
Water Resources



Environment



Old Issues



Working As a Community !



New Issues

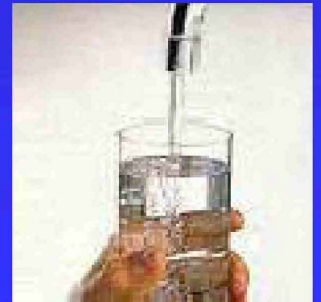


## Presented by:

Mr. Brian Oram, Professional Geologist (PG),  
Soil Scientist, Licensed Well Driller, IGSHPA

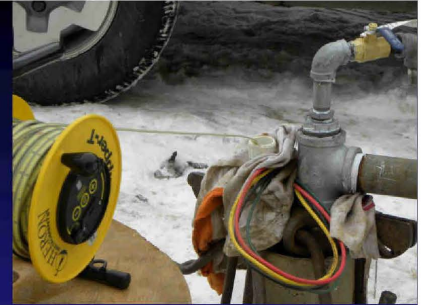
B.F. Environmental Consultants Inc.  
<http://www.bfenvironmental.com>

And  
Water Research Center  
<http://www.water-research.net>





## B.F. Environmental Consultants Inc.



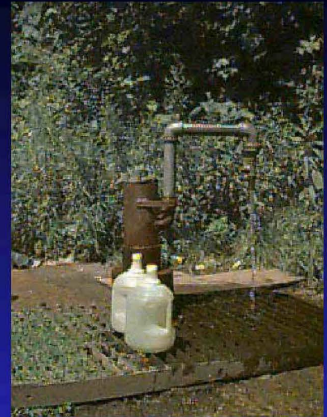
- Professional Consulting Services in the areas of water quality, soils, stormwater, geology, aquifer analysis, and land-development.
- Baseline – Chain-of-Custody
- Expert Testimony
- Water Treatment Process/ Product Development
- <http://www.bfenvironmental.com>





# Water-Research Center

Education and Outreach Program funded by  
B.F. Environmental Consultants Inc.



## Outreach Programs

- Environmental and Professional Education and Training for Citizens and Local Municipalities
- Water Quality Help Guides – Information Library
- Community and Business Outreach Programs
- Low Cost – Informational Water Testing Program with National Laboratory
- Citizen Monitoring Programs- Developing Low Cost Water Quality Sensors

Website: <http://www.water-research.net>



## EPA Sampling In Dimock

## Recent Site Tour- Towanda, PA



I took both photos – First Time on the Drilling Platform and first time watching the EPA Sample.

# Current Work

- Private Well Owner / Watershed Group Survey –  
<http://www.surveymonkey.com/s/NMG6RQ3>
- Citizens Groundwater / Surfacewater Database – Certified Data Only!  
<http://www.bfenvironmental.com>
- Radon Levels in Private Well – Goal is to Sample approximately 200 wells in Northeastern PA.  
Take the Survey:  
<http://www.surveymonkey.com/s/NMG6RQ3>

# Disclaimer/ My Goals

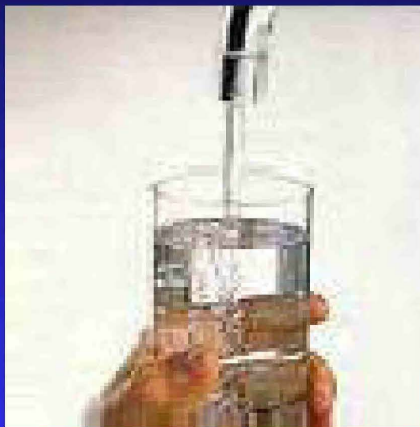
- This talk is based on my personal and professional experience.
- The presenter has not been compensated for travel or professional fees.
- This information is based on science and facts.
- The main goal of this presentation
  - ◆ Get the Waters Tested
  - ◆ Educate Citizens on Wellhead Protection/ Water Quality
  - ◆ Add to the Citizens Groundwater Database
  - ◆ Support Private Well Construction Standards
  - ◆ Fix Poorly Constructed Private Wells
  - ◆ Protect Our Groundwater Resources



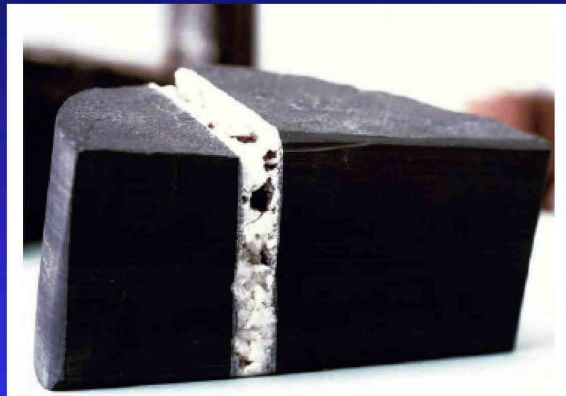
# Target Audience

- Stakeholders
- Community Advocates and Scientists
- Municipal and Local Officials
- Water Supplies and State Regulators

# Our Drinking Water



# Marcellus Shale



The Match Of the Century – Pick a Side and  
Lets See Who Wins.

No – We don't want this situation - This  
mindset is Causing all the Concern? We ALL  
Live Downstream !

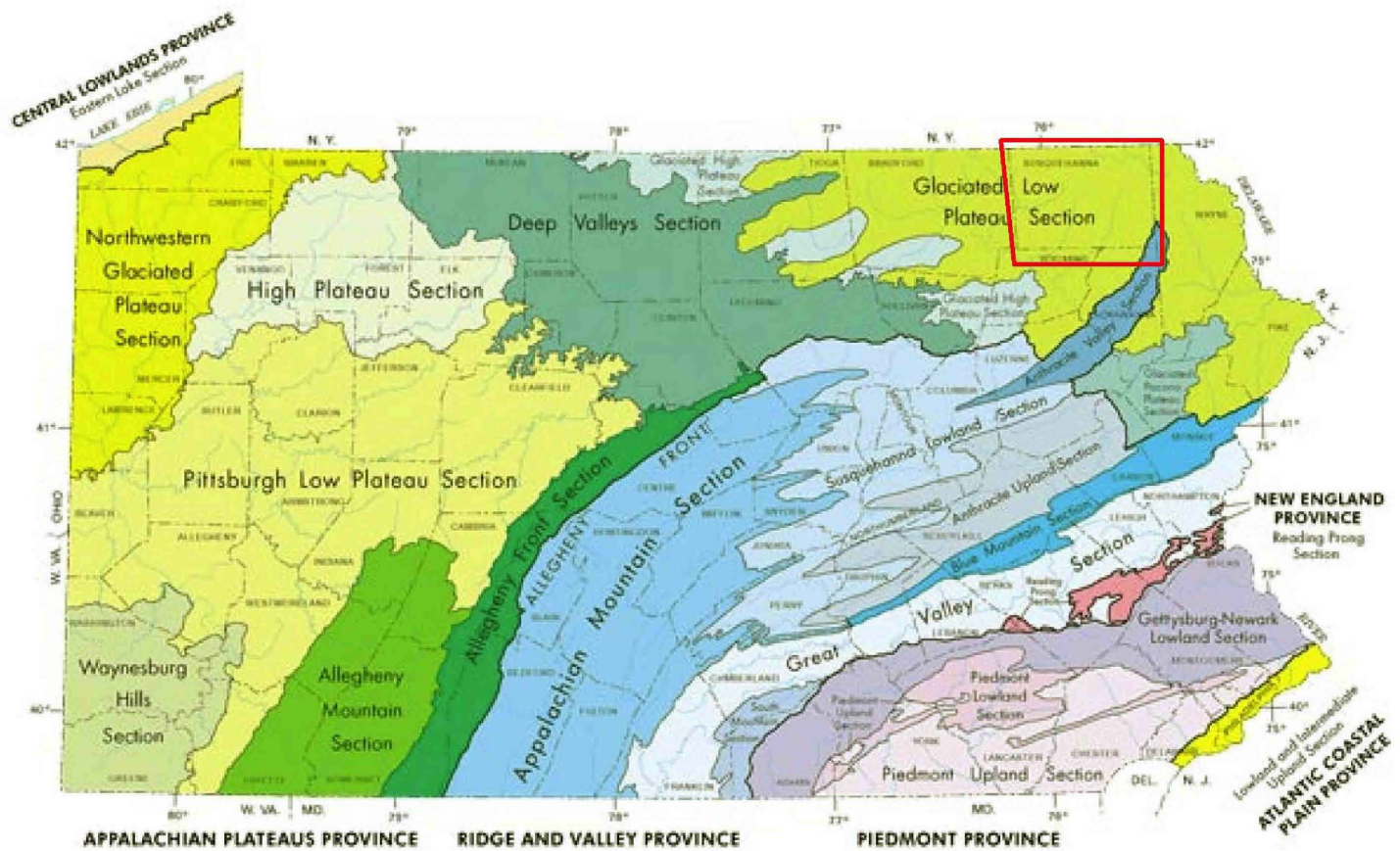
# Background

## ■ Geology/ Hydrology



Part of a 400 gallon Home Heating Oil Leak





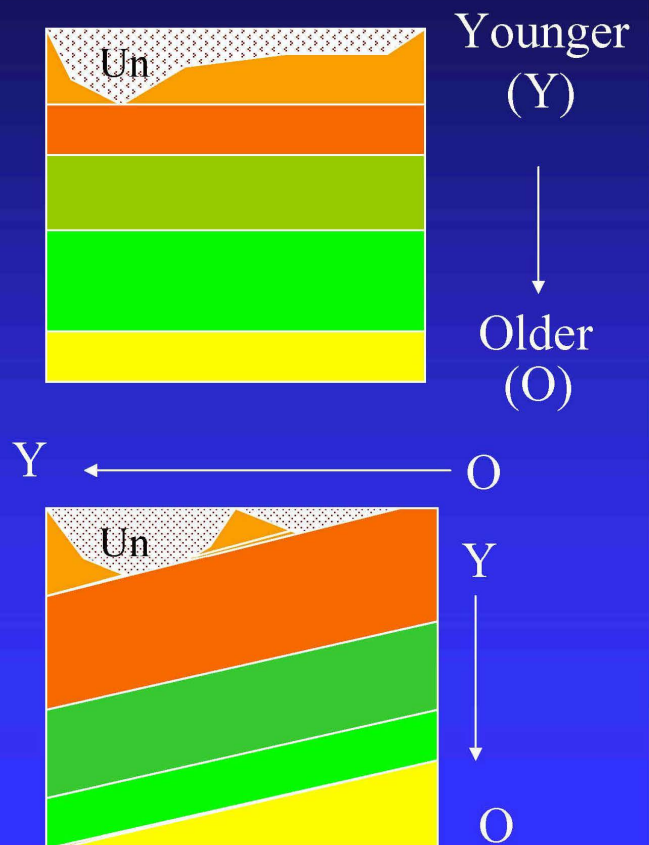
Susquehanna County was glaciated and it is located within the Appalachian Plateau

Source: DCNR - <http://www.dcnr.state.pa.us/topogeo/map13/map13.aspx>

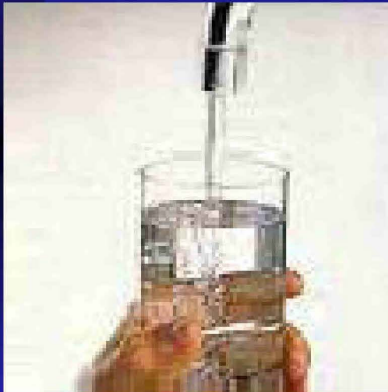
# Appalachian Plateau Province

- Broad to Narrow Valleys
- Rounded Hills and Valleys Associated with Glaciation
- Valleys filled by glacial fluvial material

Unconsolidated Material (Un)



# This is Drinking Water in PA?



50%

Corrosion

Other  
50%



Iron / Manganese



Sediment / Gases



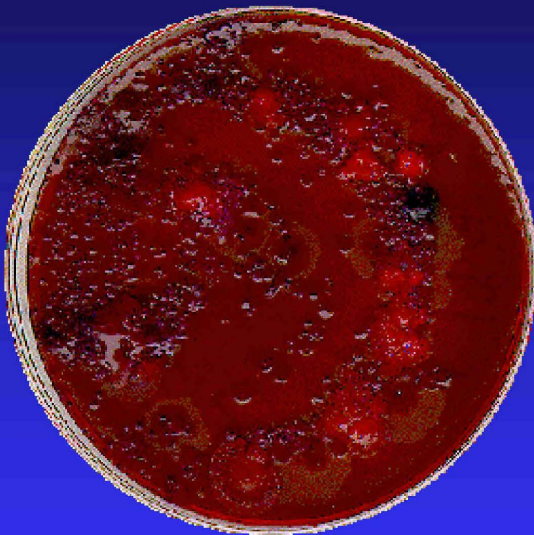
Bacteria



# PA -Private Wells Not Regulated

- Private Wells Are Not Regulated under Safe Drinking Water Act
  - ◆ EPA – NO
  - ◆ PADEP – NO
  - ◆ County – Very Few Counties in PA
  - ◆ Townships – some have basic ordinance on placement- some have comprehensive requirements
  - ◆ Where are these Wells?

Based on the geology of the NEPA and my 20 years experience, the **common** water quality problems are as follows:



Corrosive Water

Low pH

Soft Water (low hardness) to  
Moderate Hardness

Iron and Manganese

Discolored Water – Reddish  
to Brown Tints

Total Coliform Bacteria

Sulfur Odors and  
Methane- Biogenic Gas  
(Tends to be < 7 mg/L)

Radon Gas

Barium (< 1 mg/L)

Bromide (< 0.07 mg/L)

Sodium (< 15 mg/L)

- highly variable

Contamination by VOCs, SOCs,  
Glycols, Saline Water (< 3 %),  
and Radionuclides  
are NOT COMMON!

# Most Contamination appears to be associated with Total Coliform Bacteria



- Insects, Larvae and Nests / Egg Masses
- Mouse Colonies
- Snakes
- Beehives
- Mud - when casing to close to ground

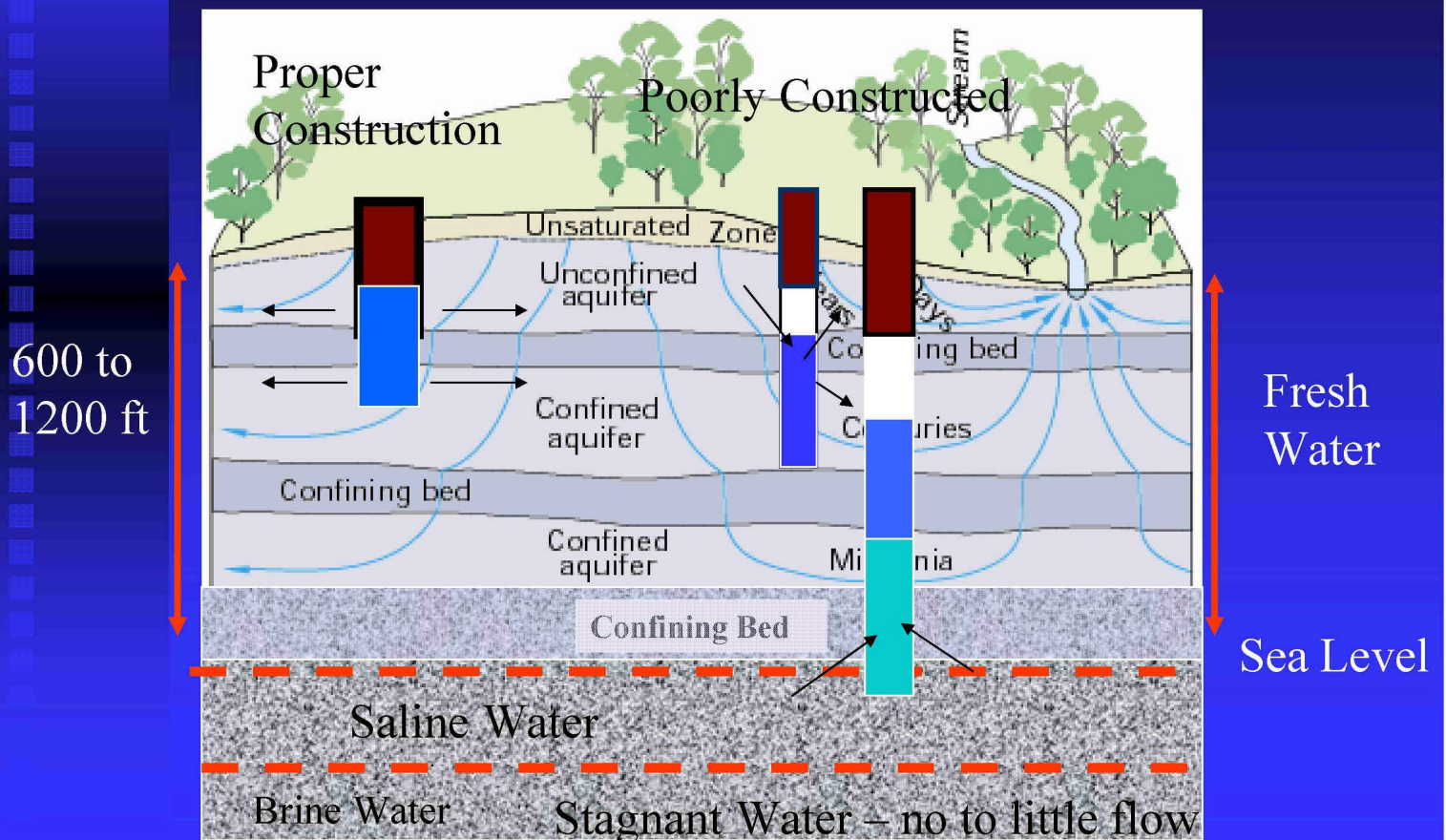
Therefore – In some cases - the Private Wells are Facilitating Groundwater Contamination.



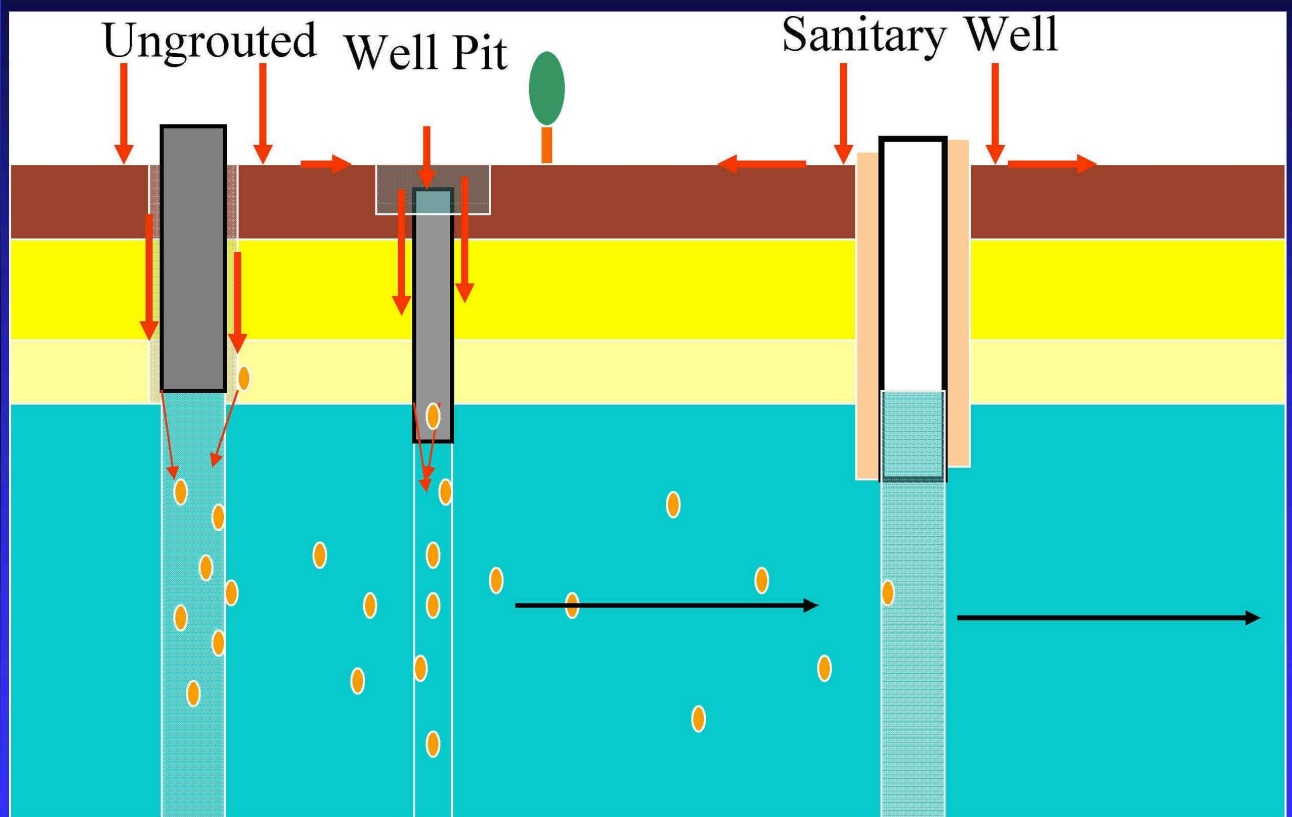
## Lets Be Honest – We have Problems in Pennsylvania with Private Wells

- Wells Poorly Constructed – either poor casing, inadequate casing, or annular space not grouted.
- Wells Too Deep – Mixing Fresh and Saline Aquifers
- Wells in the Wrong Place

# Properly Constructed Wells and Poorly Constructed Wells

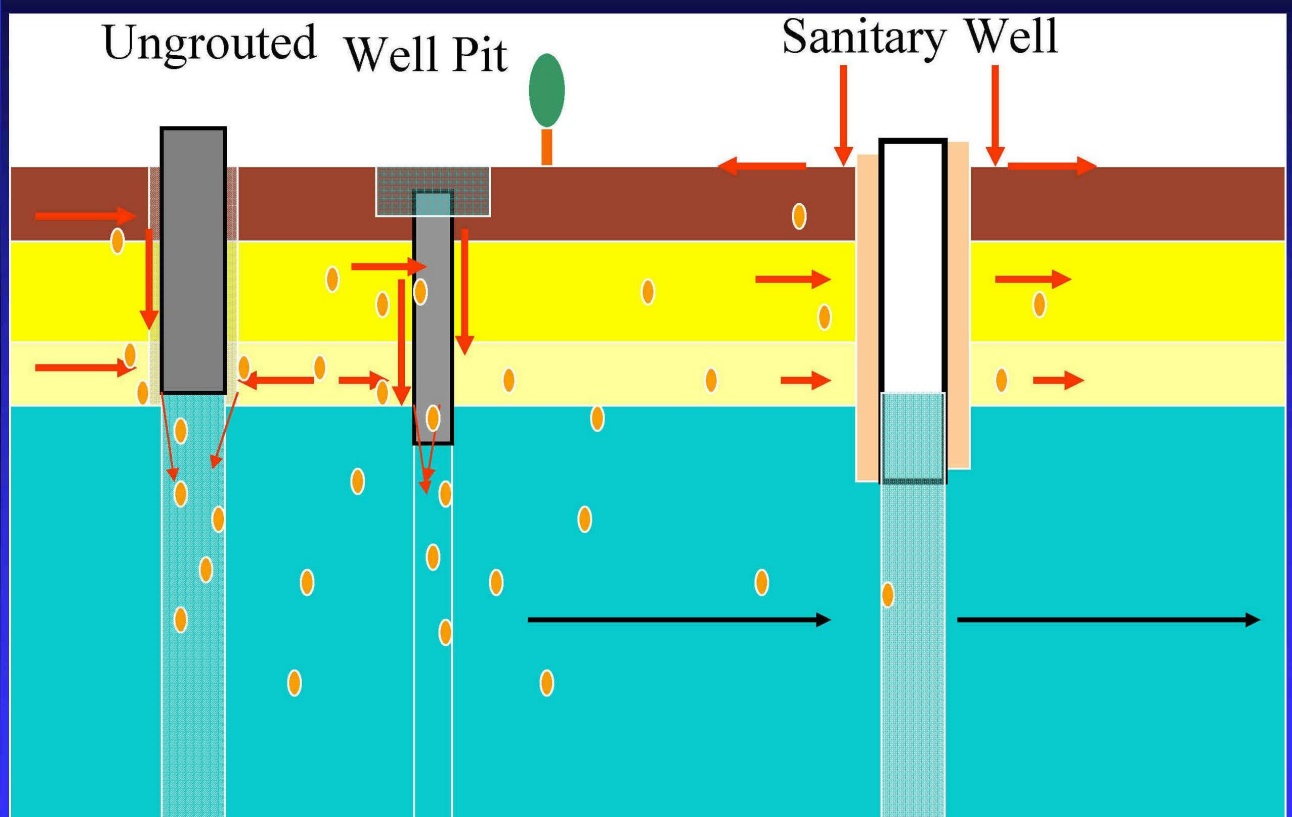


## How Contaminants Can Get In to the Aquifer (Surface)





## How Contaminants Can Get In to the Aquifer (Subsurface)



UngROUTED and Inadequate Casing of Private Wells – Facilitate Contaminant Migration

# Things I have found within 100 feet of a private well – Just a Few



By the way – these two photos are only 200 feet apart  
Groundwater is Safe and Pure – Really ?

## Before Marcellus Shale Development What was the Quality of Private Well Water?

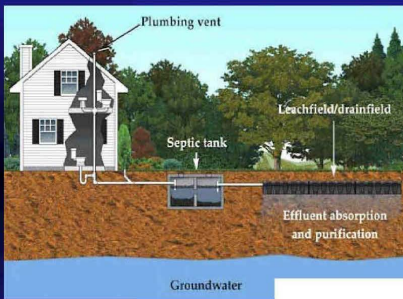
A USGS survey found that 70% of private wells were contaminated. This contamination could result in acute or chronic health concerns (1996).

Sixty-Four Percent of the identified waterborne disease outbreaks in the United States during 1999 and 2000 occurred in unregulated private water Wells. Lee et al. (2002). - **HOW MUCH DOES THIS ADD to Health Care Cost – DO WE CARE??**

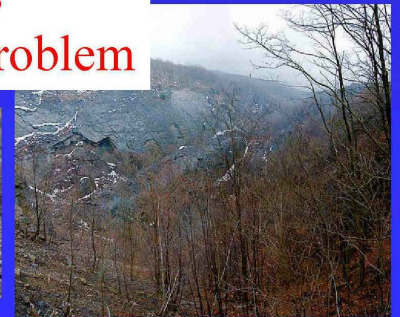
Testing Conducted by Wilkes University in through out the United States indicates that 30 to over 50% may be contaminated – Mostly by Total Coliform Bacteria – 30% of these E. coli. Positive (1989 – 2010).

PSU – Master Well Owner Network suggests that 33 to 50 % of Private Well Owners in PA may have some Form of contamination.





Not Just a Marcellus  
Shale Issue and in some cases  
other Private Wells are Part of the Problem



## Some Private Well Photos



Buried and Submerged



Wellhead Submerged  
Normally



# What is the Marcellus Shale Factor?

- We have been educating private wellowners for 20+ years- but it was difficult to get citizens to test their well water. It looks clear – I am not sick – It is fine.
- The Marcellus Shale Factor – Baseline Testing for Natural Gas Development is conducting Testing and Citizens are be told they have a Problem NOW.
- Based on Private Well Construction and Placement - Some Private Wells may be the pathways for Contamination.
- **WE NEED TO PROTECT OUR SOURCE WATER- not just from Marcellus Shale Development and other hazards, but from “us” and our past.**
- **How do we track an unregulated activity – such as: Private Wells and Identify Zones or Areas that are Vulnerable to Contamination.**
- **This lead to the idea for creating the Citizen Groundwater / Surfacewater Database**

WE Support the Citizen Groundwater Database at  
Wilkes University !





## ■ Citizen Database



What is in the Database? How you can contribute  
(anonymously to the database)  
And it is Free.

# Goal of the Database

- Provide a Central Location to Store Baseline Pre-Drilling and/or Post-Drilling Water Quality Data for the Region
- Document Quality by Geological Formation
- Identify Existing Regional Issues or Concerns
- Provide an Un-Biased Community Resource
- Provide a Mechanism to Track Temporal, Spatial, and other Geospatial Variation in Water Quality.

# Citizen Database at Wilkes University- Guidelines for Submission

## II. Guidelines for Data Submission

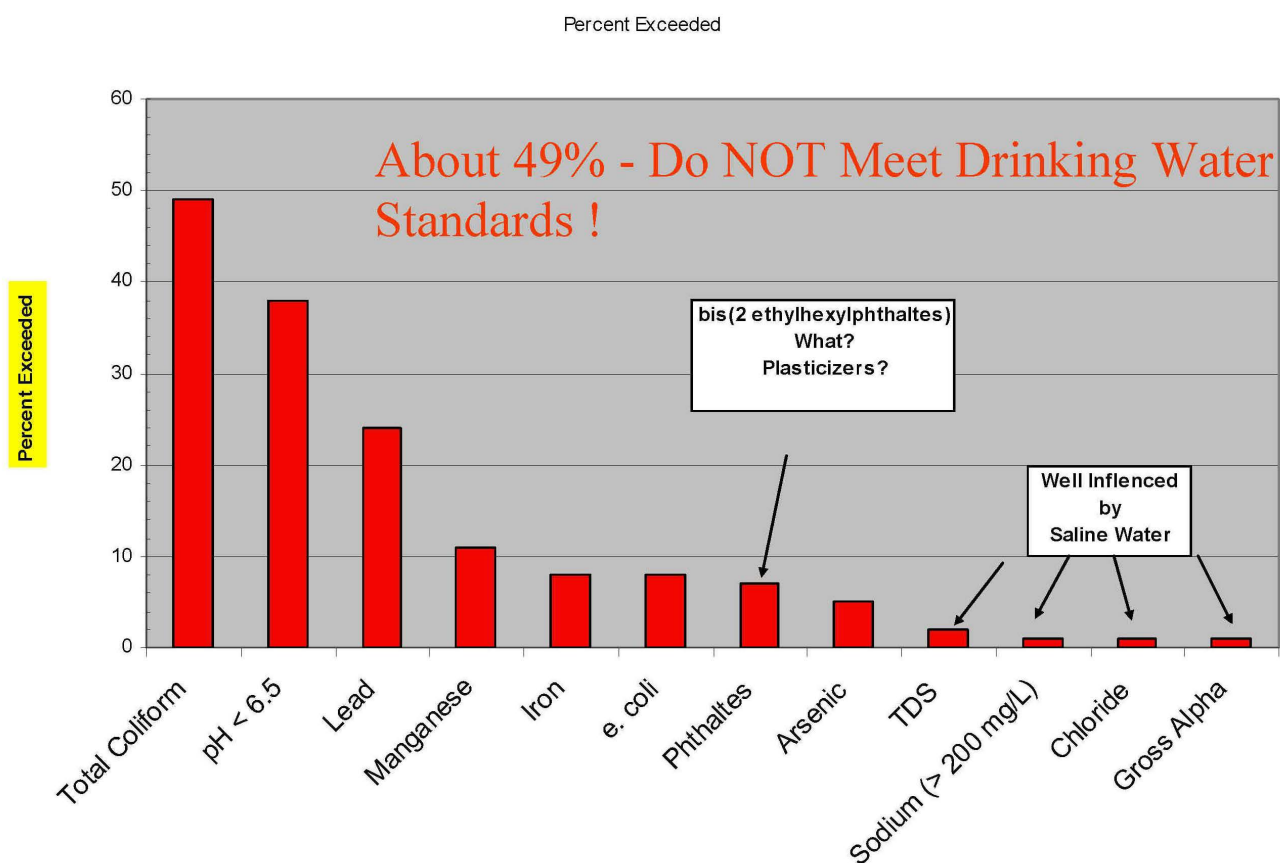
1. Third Party Samplers following chain-of-custody to certified laboratory.
2. Submit detailed reports from certified laboratory with a GPS position for the well.
3. The water sample must be collected ahead of any water treatment system.
4. other conditions – Learn More about the Wilkes University Role or at <http://www.bfenvironmental.com> bfenviro@ptd.net.

Learn More –  
<http://www.bfenvironmental.com/pawaters.php>





## Percent that Exceed a Drinking Water Standard !



# Most Contamination appears to be associated with Total Coliform Bacteria



- Insects, Larvae and Nests / Egg Masses
- Mouse Colonies
- Snakes
- Beehives
- Mud - when casing to close to ground

Therefore – In some cases - the Private Wells are Facilitating Groundwater Contamination.

# pH

$\text{pH} < 7$  acidic

$\text{pH} > 7$  basic

Drink Water Standard  
6.5 – 8.5



## Problems

- Bitter or Sour Taste
- Corrosion
- Scale Formation
- Leaching Metals- Copper, Lead, Zinc, and Aluminum
- 38 % < pH 6.5
- < 3 % > pH 8.5 (saline water)

# Corrosive Water

- Chemical or Biochemical Reaction between the water and metal surfaces.
- The corrosion process is an oxidation/reduction reaction that returns refined or processed metal to their more stable ore state.
- Corrosion can also be accelerated by:
  - 1) low pH and high pH;
  - 2) high flow rate within the piping;
  - 3) high water temperature;
  - 4) chemistry of the water/ Nuisance Bacteria;
  - 5) methane gas migration; and
  - 6) presence of suspended solids, such as sand.



Courtesy of corrosion-doctors.org

**Copper – Typically  
Blue or Blue-Green Staining**

**May also have elevated levels  
of Lead and Zinc.**



# Water Hardness, Iron, Manganese

- The hardness of a water is a measure of the concentration of the multivalent cations ( $\text{Ca}^{+2}$ ,  $\text{Mg}^{+2}$ ,  $\text{Fe}^{+2}$ ,  $\text{Mn}^{+2}$ , etc) associated with carbonates ( $\text{HCO}_3^-$ ).
- Hardness is typically reported as mg /L as  $\text{CaCO}_3$  (calcium carbonate)
- Grains per gallon (1 gpg (US) = 17.12 mg  $\text{CaCO}_3$ /L ).
- Hardness Classification:
  - ◆ Soft: 0 to 17 mg  $\text{CaCO}_3$ /L
  - ◆ Slightly Hard: 17 to 60 mg/L;
  - ◆ Moderately Hard 60 to 120 mg/L
  - ◆ Hard 120 to 180 mg/L
  - ◆ Very Hard  $> 180$  mg/L



**Secondary Drinking Water Standard**  
Iron – 0.30 mg/L (red or black) **8 %**  
Manganese – 0.05 mg/L (black) **11%**

# Problems with Iron, Manganese, and Sulfur – May be Bacterially Related



In Northeastern PA- “Nuisance Bacteria may be associated with an Odor, Iron, Manganese, or Sulfur problem. Up to 50% of the time.

Make sure to test for total coliform, standard plate count, and Nuisance Bacteria.



Natural Gas Companies should add this to their screening tests.

# What are Phthalates?

- Used as Plasticizers- is a substance which when added to a material, usually a plastic, makes it flexible and easier to handle.
- Bis(2thylhexylphthalte) (DEHP) – DW Standard – 6 ppb – GI problems, possible endocrine disruptor and carcinogen.
- Recent Testing – Highest Value was 60 ppb.
- How did this get in the aquifer?



# Arsenic- up to 6 % Elevated Levels

- The drinking water MCL is 0.010 mg/L.
- Arsenic can result in the formation of malignant tumors on skin and lungs and may cause nervous system disorders.
- Observable symptoms of arsenic poisoning are: thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in hands and feet, partial paralysis, and blindness.
- For this particular parameter within Northeastern Pennsylvania (NEPA), it would be advisable to retest the water for dissolved and total arsenic.
- In many cases, the arsenic has been leached from a colloid or particle that could be more cost effectively removed by standard filtration. It is also typically bound to iron oxide complexes.

## Comments on Sodium

- Sodium – Not regulated by the EPA – not a primary or secondary drinking water standard.
- Sodium – Background Levels – Mean 15 mg/L (Pre-drilling - < 1 to 630 mg/L)
- Most Pre-Drilling Elevated Levels of Sodium associated with Road Salt or Saline Water Intrusion.

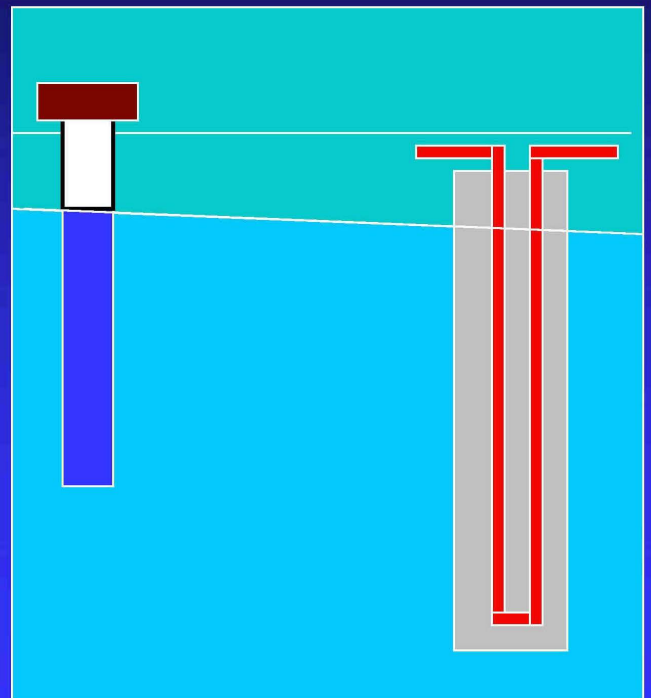
## Comments on Bromide

- Bromide – Not regulated by the EPA – not a primary or secondary drinking water standard.
- Bromide – Background Levels – Mean 0.07 mg/L (Pre-drilling - < 0.01 to 6.2 mg/L)
- Most Pre-Drilling Elevated Levels of Bromide associated with Saline Water Intrusion.



# Glycols- not a common problem – no real drinking water standard

- ground-water heating and cooling systems, deicing agents, and natural gas development
- EPA guidance is  $\leq 7000$  ppb or 7 mg/L (ethylene glycol)



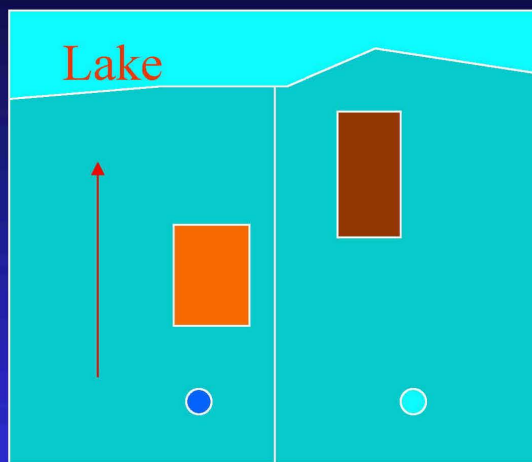
Private Well

Ground Surface Well

## Impact Where There is NO Drilling – Baseline Testing

Well A

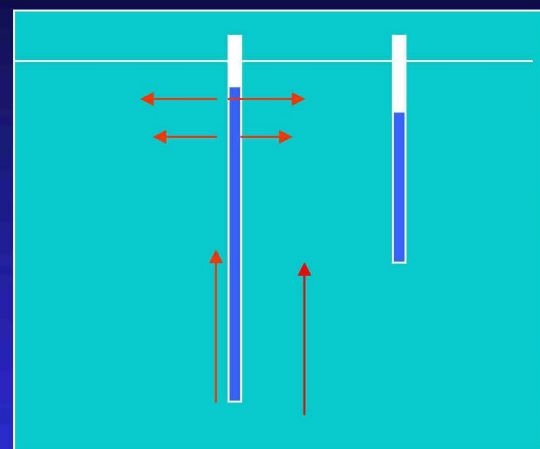
Well B



Groundwater Flow Towards  
The Lake

Well A

Well B



Direction of Groundwater  
Flow - UP

### Well A- 300 feet

Methane – 10 to 15 mg/L – the real problem, Barium 4 mg/L, Radon 577 pCi/L,  
Chloride 250 + mg/L, Bromide 1.5 mg/L, Strontium 5.57 mg/L, Iron – 3.2 mg/L

### Well B – 200 feet

Methane – 6 mg/L, Chloride 30 mg/L, Barium 1.13 mg/L, Strontium 2.15 mg/L,  
Radon < 60 pCi/L, Iron – 1.39 mg/L

Well A may be Impacting Well B

# Methane Gas Migration

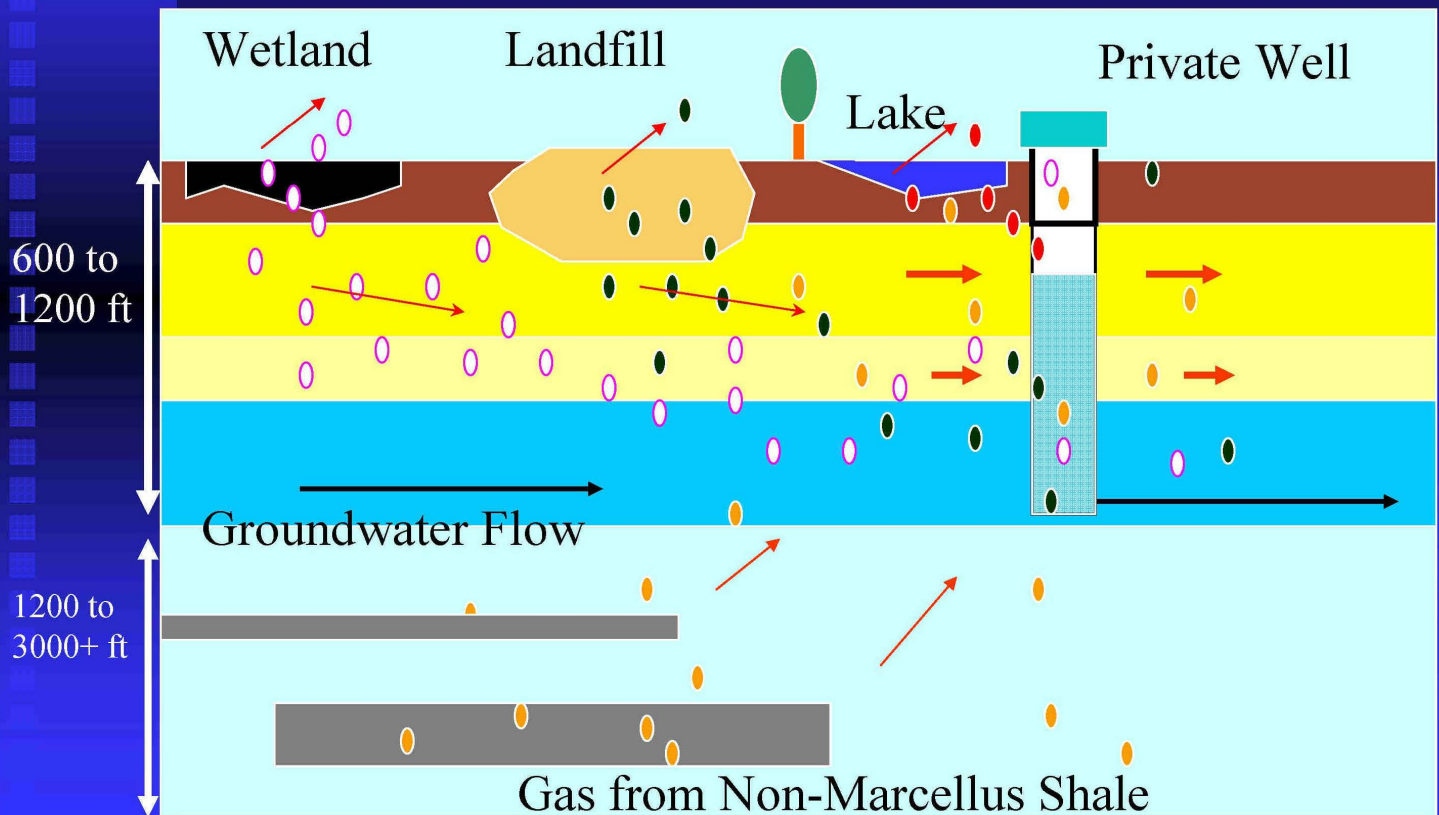
- Shallow Gas
- Natural Migration
- Facilitated Path – because of Private Wells
- Induced Migration



# Methane in Water

- Methane has been a hidden issue in NEPA.
- The gas is colorless, tasteless, and odorless and there are no known health effects.
- Potential concerns relate to flammability/explosiveness of gas.
- Background – appears to range from non-detect to over 20+ mg/L (highly variable) in Northeast Pennsylvania.
- I lite my first well water sample in about 1989- thanks to methane gas.

# Methane Gas Migration- Not Related to Marcellus Shale

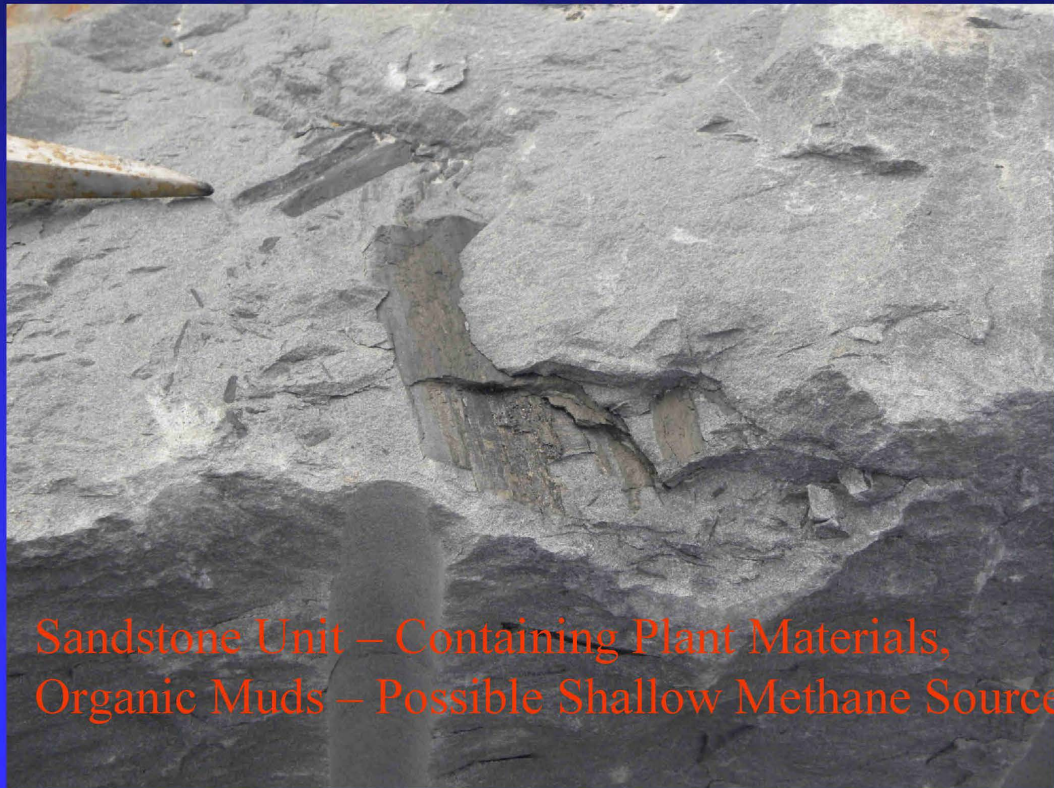


# Methane (a little more)

- The Coal regions and northern portion of NEPA, and areas associated with the Mahantango / Marcellus Shale may have elevated levels of methane.
- No drinking water limit, but Office of Surface Mines recommends monitoring for concentrations from 10 to < 28 mg/L and immediate action for concentrations > 28 mg/L
- My Recommendations (Oram, 2009):
  - ◆ < 2 mg/L – Monitor annually with passive venting, annual testing
  - ◆ > 2 to 7 mg/L – Monitoring with active venting- Twice a Year for One Year (During Times Out-gassing is Severe).
  - ◆ > 7 mg/L to < 10 mg/L – active venting, pump shroud, isotopic analysis. Quarterly Testing for one year.
  - ◆ > 10 mg/L – Treatment , active venting with more aggressive management, isotopic analysis , and possible well rehabilitation- Monthly testing for up to one year.

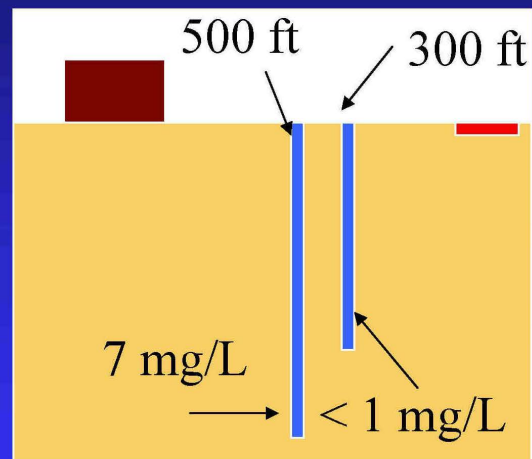
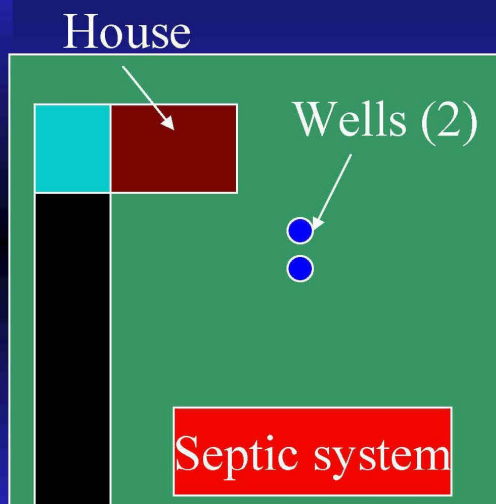


# Rock Sample from Quarry – West of Dimock



Sandstone Unit – Containing Plant Materials,  
Organic Muds – Possible Shallow Methane Source

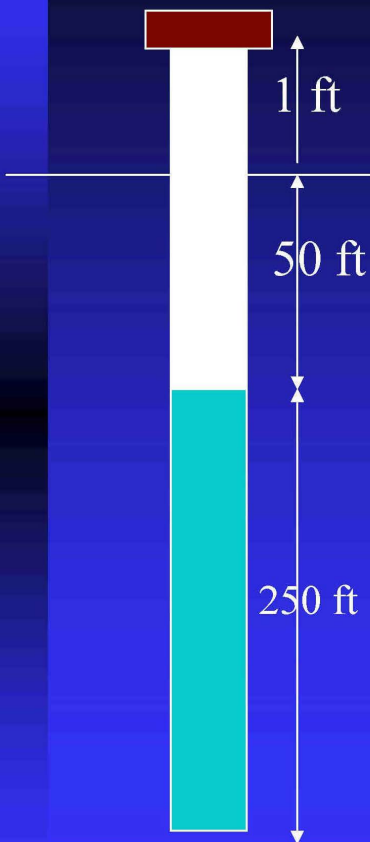
# Methane Variability- Actual Examples- Well Depths



## Methane Gas Level – Change over Time- Time with Highest Levels

- barometric pressure is low and soils are saturated;
- when snow cover is just beginning to melt;
- the ground is frozen or ice covered; or
- under long-term pumping conditions for the well when the well is experiencing the lowest dynamic water level and greatest drawdown.

## Estimating Specific Capacity



Specific Capacity =  
Gpm/ft of drawdown

gpm = 5 gpm

Static Water Level – 50 feet

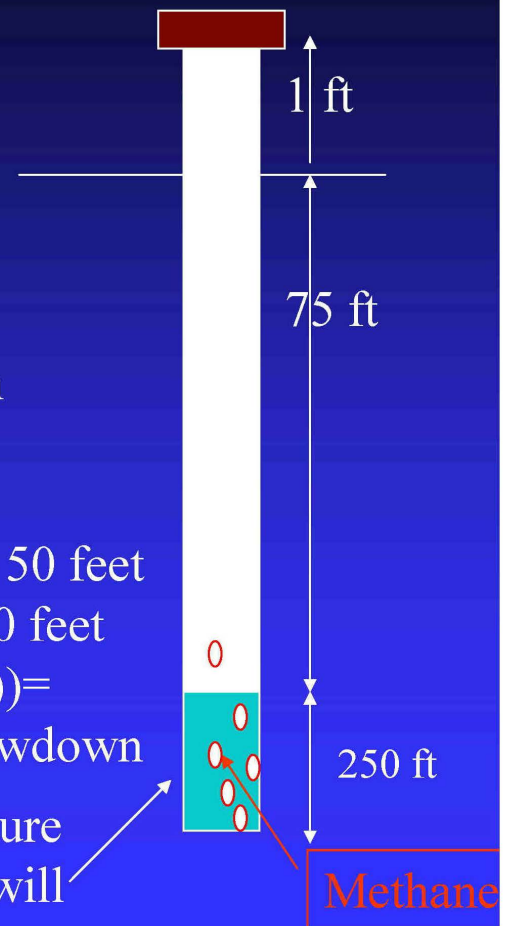
Dynamic Level – 200 feet

$Sc = (5 \text{ gpm} / (150 \text{ ft})) =$

$Sc = 0.03 \text{ gpm/ft drawdown}$

Less head pressure

More methane will  
be released.







Ok – I get the outgassing – by why is it brown?



Does this Look Familiar?

Part of the Reason for the Discolored Water May be Iron Bacteria  
Iron Related Bacteria is a common problem in NEPA –About 50%  
of Wells with an Iron Problem or Coliform Problem have IRB.

I am not saying there is no methane gas in the water.

Water has a  
Purple Hue !



Oram, 2011  
Susquehanna County, PA

### Example of Nuisance Bacteria Causing Corrosion

Iron Related Bacteria Count - > 140,000 colonies per ml

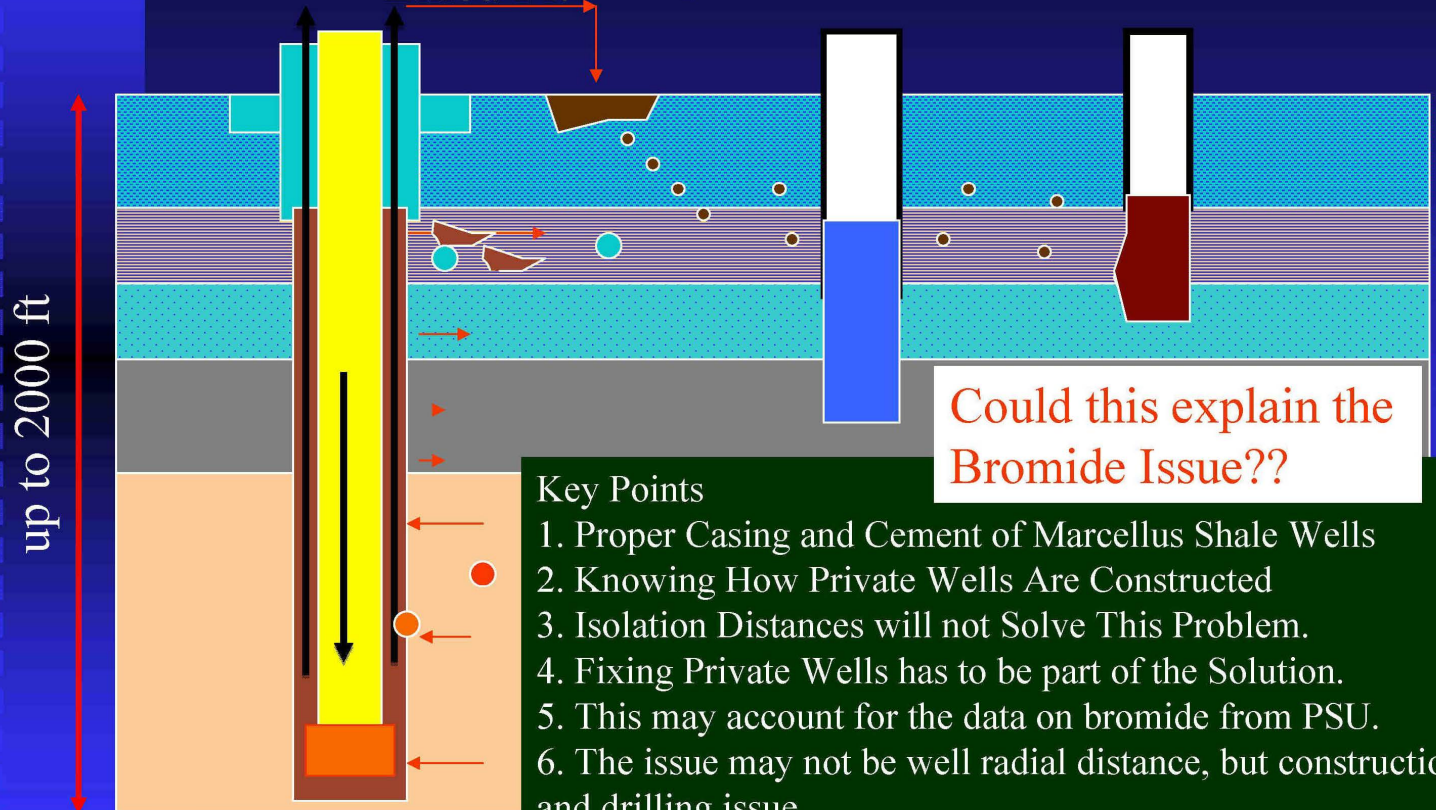
Aluminum – 0.511 mg/L, Iron 1.87 mg/L, Manganese – 5.4 mg/L,

Lead 0.029 mg/L, Methane - < 0.001 mg/L



## PSU Study -Migration and Disturbance During Drilling-losing circulation

Lined Pit Proper Construction Poor Construction



Could this explain the Bromide Issue??

### Key Points

1. Proper Casing and Cement of Marcellus Shale Wells
2. Knowing How Private Wells Are Constructed
3. Isolation Distances will not Solve This Problem.
4. Fixing Private Wells has to be part of the Solution.
5. This may account for the data on bromide from PSU.
6. The issue may not be well radial distance, but construction and drilling issue.
7. Recommend closed loop drilling with water within freshwater aquifer (no muds) or water-based muds.



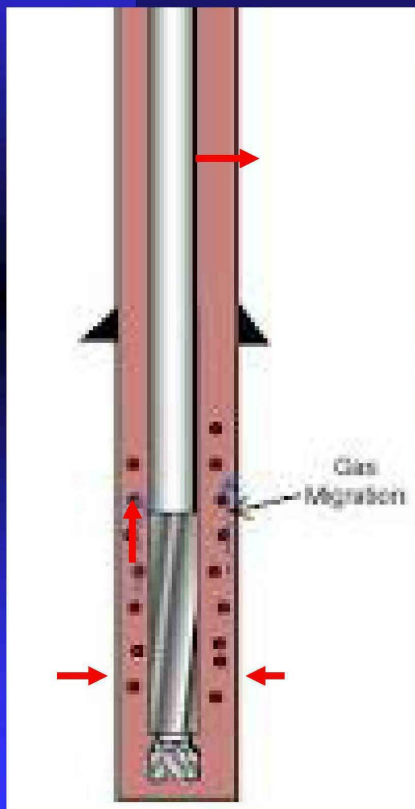
# General Geology- Northern Tier PA



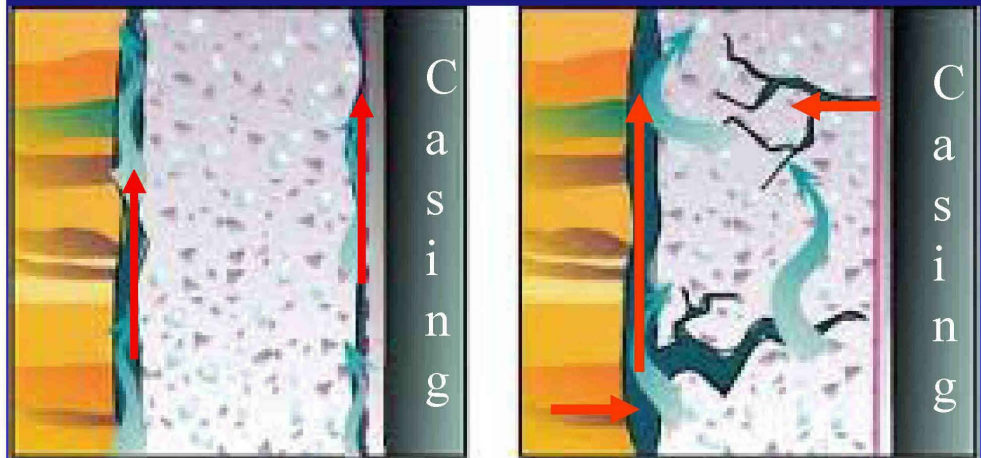
# Protective Casing – Do it Right !



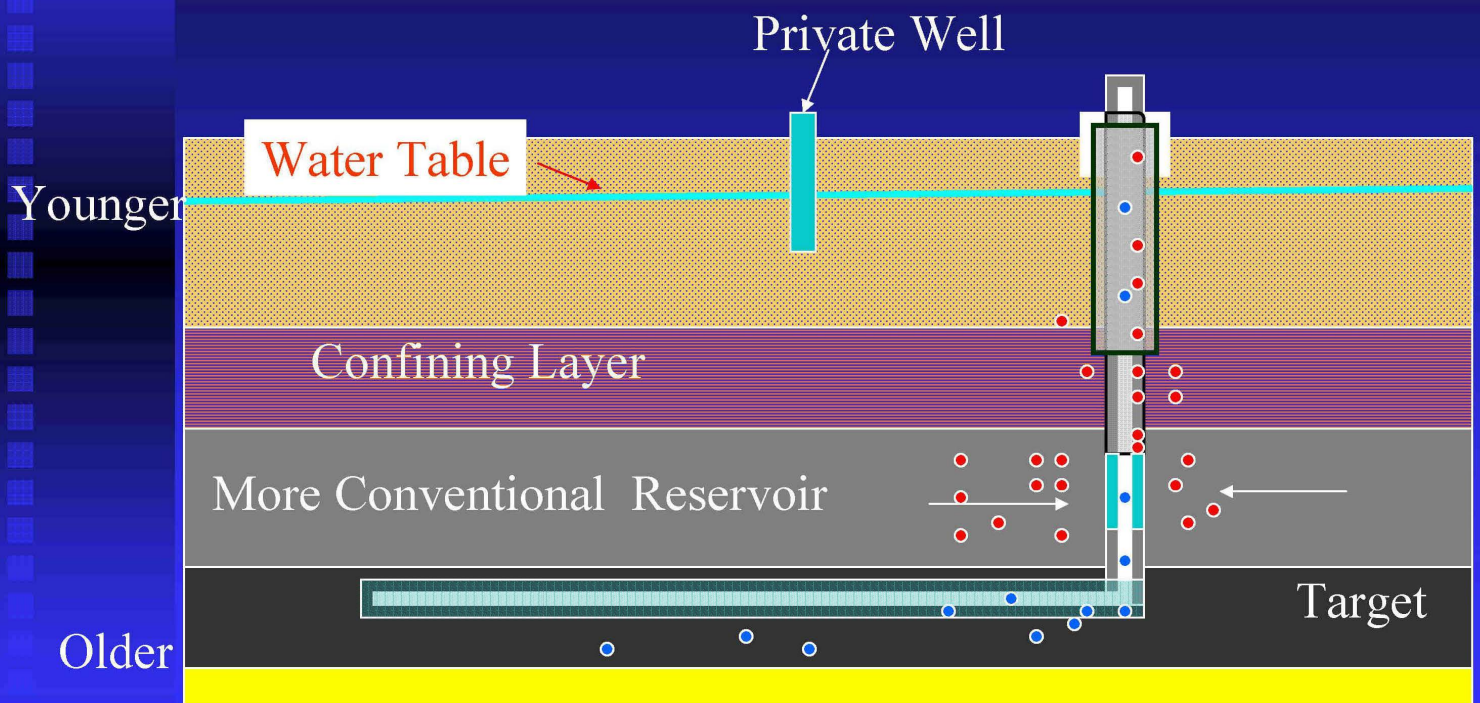
# Problems with Gas Migration and Cement



Does not Bound



# Migration Concepts- Multiple Casements and Recreate Confining Layers- Need Good Cement Bonds- Cement up to Deepest Casement or Surface

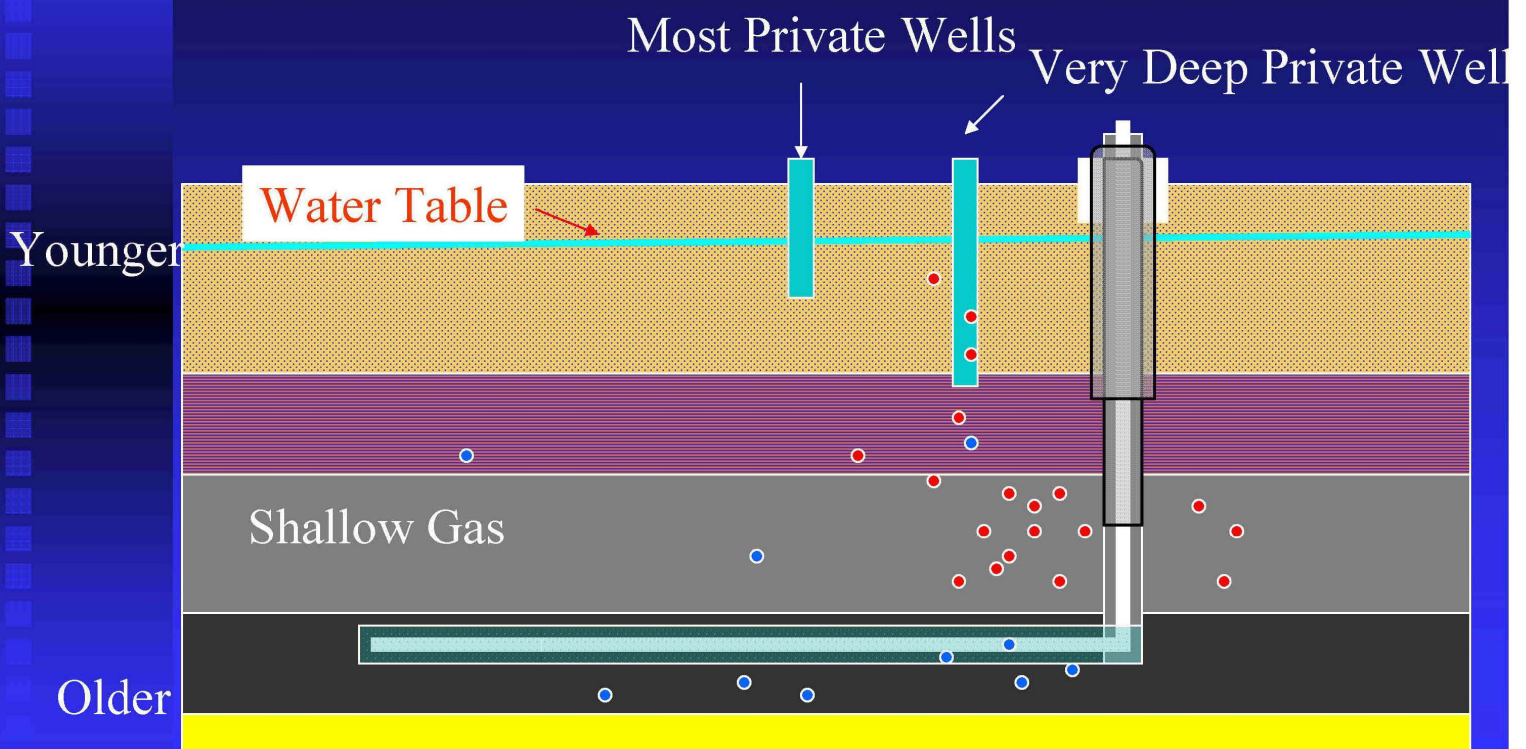




# Changes in the Regulations or other Work a Local Task Force Approach

- Require cement bond-logging.
- Require a self-contained liner system.
- Require cementing borehole to the surface or at a minimum the inner most string of casing with pressure monitoring.
- Require the development of private well owner impact plans that outline what is to be done and steps taken to address a suspected private well impact.
- Consider creating an information document that tells private well owners their rights, whom to call, when to call, and where to get help.

## Migration Concepts- Multiple Casements and Recreate Confining Layers – No Uncemented Zones.

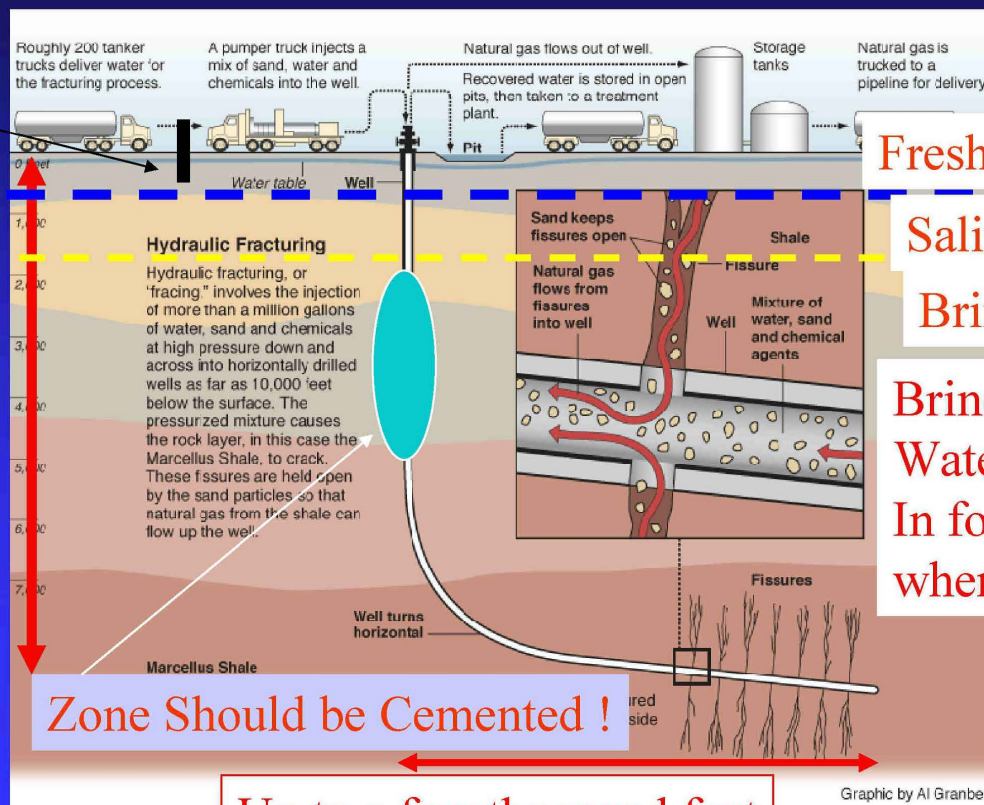


The other Problem – Private Wells that are Too Deep – I aware of some private wells that are over 900 feet deep.

# Getting to The Natural Gas

Freshwater Well

5000 to 7000 feet



Freshwater

Saline  
Brine

Brine / connate  
Water- Trapped  
In formation  
when deposited



# Changes in the Regulations

- Require Lined Sites with Containment.
- Require Data to be Posted on Frac Focus- <http://www.fracfocus.org>  
(Post data as percent and concentration)
- Require Cement Bond Logging.
- Require Cementing to Surface for all strings and production casing and protection of saline aquifer (Consistent with EPA UIC Program).
- Require Monitoring Private Wells During Drilling Process – Field Screening Only
- Increase baseline testing zone to cover the anticipated capture zone for the well pad.
- More Cased Zones – Multiple Cement Casing
  - ◆ New Strings – Placed Based on Local Geology and Well Survey
    - ◆ Shallow Freshwater
    - ◆ Deeper Freshwater
    - ◆ Saline Zone Casing



# Frac Water Chemical Disclosures

- FracFocus”- <http://fracfocus.org/>. - the hydraulic fracturing chemical registry website.
- This website is a joint project of the Ground Water Protection Council Interstate Oil and Gas Compact

# What Local Leadership Can Do?

- Promote Education and Outreach Programs and Get Informed
- Encourage Gas Companies to Have Copy of Permit Available Locally for Review
- Have Open Discussion with Gas Companies and Royalty Owners
- Encourage Citizens to Participate in Baseline Testing
- Use Baseline Data to Make Decisions – it is not just a formality !
- Private Well Construction and Siting Standards
- Develop a Way to Fix Poorly Constructed Private Well – “We all live downstream”.
- Monitor Private Wells During the Drilling / Development Process
- Develop Community Support Program – Central Location Where Citizen Can Call and Get Answers – NOT the Run-a-Round.
- Promote Solutions that fix a problem – not just treat the symptoms (New Fact Available)
  - ◆ Cementing Portions of Wells that are too deep.
  - ◆ Pump Shrouds
  - ◆ Extending Casing – Using Liners in Private Wells

Support the Citizen Groundwater/ Surfacewater Database  
WE ALL LIVE Downstream ! (Send No Money – Just Data!)

# Again

Up to 1.5 Million - Citizens in PA Drink Water that may cause short term or chronic disease. This has nothing to do with Marcellus Shale Oil and Gas Development, Or Unconventional Gas.

This needs to have attention – NOW!

This is not a Marcellus Shale Issue- it is a Health Care and Economic Issue for the State of Pennsylvania.

We NEED to Work as a Community and Fix The Problems We Created.

Do we really want to Control Health Care Cost??

**This is not a Marcellus Shale Issue – It is a HEALTH Issue !**

# Consider Vulnerability Analysis

- Is the Well Shallow?
- Is the Well Cement Grouted?
- How deep is the Casing?
- Does the Well Show Signs of Saline Water or Elevated Methane ? – Pre-Drilling
- Does the well have an elevated level of bacteria, chloride, sodium, or intermittent discolored water?
- If so – this may be a well that is vulnerable to surfacewater or near surface influence and act as a pathway to contamination or a pathway for “saline water”.
- This well should be inspected, fixed, upgraded, or abandon.



# Certificate of Completion

## Training Event

Getting The Waters Tested The Marcellus Shale Factor  
Working as a Community

2/2/2012

3 – hour PDH or 0.3 CEUS

Presented by

Mr. Brian Oram, PG

B.F. Environmental Consultants Inc

15 Hillcrest Drive

Dallas, PA 18612

More Online Training @

<http://www.bfenvironmental.com>





## Presented by:

Mr. Brian Oram, Professional Geologist (PG),  
B.F. Environmental Consultants Inc.  
<http://www.bfenvironmental.com>

And

Water Research Center  
<http://www.water-research.net>

Private Well Owner – Watershed Survey  
Free Radon in Water Test (200 samples)  
<http://www.surveymonkey.com/s/NMG6RQ3>

Marcellus Shale Training Event – 3/9/2012  
(9:00 – Noon) – Wilkes University